

EFFECT OF AN EROSIVE CHALLENGE ON THE ENAMEL-COMPOSITE RESIN INTERFACE IN PRIMARY TEETH: AN IN VITRO STUDY

ABSTRACT

AIM: The aim of this study was to evaluate whether different adhesive systems (etch-and-rinse or self-etch) render enamel-composite resin interface in primary teeth more susceptible to erosive challenge. **MATERIAL AND METHODS:** Thirty enamel specimens from caries-free primary incisors were selected and cavities were prepared for restoration. According to adhesive protocols, specimens were divided into groups: G1 (Adper Single Bond 2), G2 (Adper SE Plus), and G3 (35% phosphoric acid + Adper SE Plus). After restorative procedures, half of the surface of enamel and restorative material was protected with nail varnish, thus, only half of the sample was subjected to the erosive challenge (immersion in Coca-Cola®, 3 cycles of 5 minutes, for 5 days). Samples were analysed quantitatively through Knoop microhardness, the indentations were made on enamel-composite interface. Data were submitted to statistical analysis (Student's t test, two-way ANOVA, $p < 0.05$). **RESULTS:** It showed that different adhesive systems did not significantly affect the percentage of superficial microhardness change after an erosive challenge ($p = 0.387$). However, although no significant difference was observed, G2 (self-etch system) showed the lowest percentage of superficial microhardness change. **CONCLUSION:** The use of different adhesive systems did not influence superficial microhardness of enamel-composite interface after an erosive challenge. The incomplete removal of the smear layer, though self-etch systems, suggests a greater ability to withstand the erosive challenge on the enamel-resin interface.

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KEYWORDS

Deciduous tooth. Adhesion. Tooth erosion.

INTRODUCTION

In recent decades, changes in lifestyle and diet, including a higher intake of acidic beverages, has introduced consequences for oral health in the increased prevalence of dental erosion. This prevalence has been reported to range from 10% to over 80% in children.¹ The primary dentition is thought to be more susceptible to erosion compared to the permanent dentition due to the thinner and less mineralised enamel.¹

Due to the convenience of consumption, there had been an increase in the intake of industrialised foods, soft drinks, artificial juices and sports drinks, which are consumed mostly by children and adolescents.² The amount and frequency of consumption of soft drinks has increased significantly in recent decades, with values 300% higher in some countries.³ Therefore, dietary factors have been considered to be the most important external risk factors for dental erosion in children and adolescents.²⁻⁷

Several studies have evaluated the erosive potential of products (regular and light soft drinks, juices, chewing gums) on different surfaces (human or bovine teeth, enamel or dentin, restorative materials) and the effect of these products on mineral loss, microhardness and surface morphology.^{2,4,5,7-13} However, few studies have focused on primary teeth.^{2,7,10,13}

Dental erosion often co-exists with attrition and abrasion and may cause tooth

sensitivity, aesthetic damage and loss of the occlusal vertical dimension.¹ The use of adhesive techniques and composite has demonstrated its potential, for the rehabilitation of moderate tooth wear. Modern hybrid composites are the materials of choice to restore directly or indirectly anterior and posterior teeth as well.¹⁴ However, it is known that the longevity of restorations is directly related to the durability and mechanical properties of the material. Restorations are also constantly subjected to thermal, mechanical and chemical challenges^{4,14-20}. An effective restorative treatment should consider these conditions in order to achieve better results.

Adhesive systems have been developed and classified into two main categories: etch-and-rinse (two- and three-step adhesives) and self-etch (one- and two-step adhesives).²¹ These adhesive techniques do not present major difficulties in its application, and have shown adequate bond strength values.^{22, 23} On the other hand, the effectiveness of adhesion on eroded enamel remains unclear.

As primary teeth are more reactive to etching and because self-etching systems have a higher pH, dispenses rising and are less aggressive to the substrate, these systems are likely ideal for use in paediatric dentistry^{22, 24-28}.

Another reason for this indication is the fact that self-etching systems decrease the

clinical time while simultaneously reducing the possibility of technical failure.^{27,28} A less time-consuming technique using any adhesive system is always preferred in paediatric restorative dentistry. Thus, the inclination towards the selection of adhesive systems may lean towards the self-etching bonding system at this juncture.

The impact of erosive challenge on primary teeth restored with restorative dental composite remains underexplored despite the increased prevalence of dental erosion. Therefore, this study aimed to assess whether different adhesive systems (total removal of the smear layer or modification of the smear layer) render the primary teeth substrate more susceptible to erosive challenge.

MATERIAL AND METHODS

After approval from the Ethics Committee (#09.147.4.02.III), 35 primary caries-free incisors were chosen. All teeth were donated by patients' responsible after exfoliation after signing a donation form.

Thirty five recently extracted caries-free primary human incisors with no cracks on the buccal surface were initially selected. Teeth were cleaned with pumice and water, stored in 0.5% Cloramine T solution and frozen for a maximum of 3 months, until the start of the experimental procedures. The crowns were separated from the roots using an ISOMET Low Speed Saw cutting machine (Buehler, Lake

Bluff, IL, USA). Each enamel specimen was embedded in polystyrene resin (Cromex, São Paulo, SP- Brazil). The enamel surface was ground flat with water-cooled carborundum discs (240 a 600 grades of Al₂O₃ papers; Buehler, Lake Bluff, IL, USA) and polished with wet felt paper and diamond spray (1000, 1200, 1500 and 2000). The final polishing was performed with a filter disc and abrasive alumina (0.5 µm granulation).

For sample surface homogenisation, Knoop microhardness tests were performed (3 linear indentations, 100 µm apart from each other, 25g, 5s, HMV-2000; Shimadzu Corporation, Tokyo, Japan). Visual reading and calculation of microhardness indentations were performed using the CAMS Testing System software (Newage Testing Instruments, Feasterville, USA), installed on a computer connected to the microhardness tester through optical digital transfer imaging. Final hardness values were obtained from an average of three indentations. Five samples were excluded because their microhardness values had high levels of variation (standard deviation higher than average values). Samples were evenly distributed among the 3 groups (n=10) according to the adhesive system used, and all groups were composed of enamel samples with similar microhardness values: Group 1 (G1, Adper Single Bond 2), Group 2 (G2, Adper SE Plus), and Group 3 (G3, 35% phosphoric acid + Adper SE Plus).

Next, cavities were prepared initially with a cylindrical bur (KG # 1094, KG Sorensen Ind. e Com, Barueri, SP, Brazil) with an active diameter of 1.2 mm. After obtaining a 1.2 mm deep cavity, a diamond bur (KG #1057) with an active diameter of 1.8 mm and length of 2.6 mm was used to increase the cavity width. The dimensions of the cavity were approximately 1.8 mm in diameter and 2.6 mm in depth. The burs were replaced every five procedures.

After preparation of the cavities, adhesive protocols and restorative procedures were performed according to the selected materials described in table 1.

All enamel samples were restored following the same protocol using shade A2 Filtek Z250 restorative dental composite in 1 mm-thick increments with the aid of a spatula; the samples were then polymerised for 20 seconds with a halogen light (Curing Light 2500, 3M ESPE Elipar™, light intensity 470 mW/cm², 3M ESPE, São Paulo – SP - Brazil).

The samples were immersed in distilled water and stored at 37°C for 24 hours. The finish was accomplished with the aid of golden series 1190F dental burs (KG Sorensen Ind. e Com, Barueri, SP, Brazil) and silicone tips (Enhance, Dentsply Ind. e Com Ltda, Petrópolis, RJ, Brazil). Polishing pastes were used (Fotogloss Kota Imports Ltda, São Paulo, SP, Brazil) in two granulations (Poly I and II) with the aid of a rubber cup (Viking - KG Sorensen Ind. e Com, Barueri, SP, Brazil) at low speed for

the final polish. Any residue of adhesive that could have spread the enamel around the cavity and could interfere with the measurement of microhardness in the tooth-restoration interface was removed during polishing procedures.

Another microhardness assessment was made to evaluate the mineral loss after adhesive and restorative procedures. After that, two layers of nail varnish were applied on half of the surface of enamel and restorative material; thus, only half of the sample was subjected to the erosive challenge.

Each specimen was immersed in 50 mL of regular Coca-Cola® (pH 2.6, Coca-Cola Company, São Paulo, SP, Brazil) for five minutes, three times per day (8h, 14h and 20h), under constant shaking at room temperature. These procedures were repeated for five days. Between the erosive challenges, the specimens were rinsed in distilled water and immersed in artificial saliva (potassium chloride, sodium chloride, magnesium, calcium chloride, monopotassium phosphate, sodium fluoride, sodium dihydrogen phosphate, ammonia, albumin, ureia, basal amino acids, vitamins, deionized water)²⁹.

The final Knoop microhardness measurement was performed in the manner described above for sample homogenisation. Six indentations were made on each specimen, on the enamel-composite resin interface, three on the previously protected enamel surface

and three on the experimental area. The average percentage superficial microhardness change (%SMHC) was calculated using the following equation:

$$\frac{(\text{Experimental area hardness} - \text{Protected area hardness}) \times 100}{\text{Protected area hardness}}$$

Data analysis was accomplished with the use of SPSS 18.0 (Statistical Package for the

Social Sciences®, Version 18.0, Chicago, USA). The assumptions of equality of variances and normal distribution of errors were checked for all the variables tested. Because the assumptions were satisfied, Student's *t* test and a two-way ANOVA were performed for statistical comparisons, and the significance level was set at 5%.

Table 1. Materials used in the study.

Material	Manufacturer
35% Phosphoric acid (PA35%)	3M/ESPE, St. Paul, MN 55144 – USA; lot: 9SG
Adper Single Bond 2	3M/ESPE, St. Paul, MN 55144 – USA; lot: 7LW
Adper SE Plus (self-etching)	3M/ESPE, St. Paul, MN 55144 – USA; lot: 8BE e 8BB
Filtek Z250	3M/ESPE, St. Paul, MN 55144 – USA; lot: 7LG

RESULTS

As expected, a statistically significant difference was found between baseline microhardness and microhardness after erosive challenge in all adhesive systems. Likewise, no significant difference in the microhardness values of protected enamel surfaces after the experimental phase was observed (Table 2). It was observed that the different adhesive systems did not differ from each other in the loss of surface microhardness (Table 3). Although the specimens of Group 2 (Adper SE Plus) showed the lowest loss of surface microhardness, no significant difference was observed (Figure 1).

DISCUSSION

In the presence of erosive challenge, several studies showed that all restorative materials degrade over time.^{8,10,30} Thus, the failure of the tooth-restoration interface can cause the formation of cracks and, consequently, microleakage, postoperative sensitivity, recurrent caries, and even pulp damage.^{14-17,19}

According to the results obtained in this study, it was observed that regardless of the mechanism of action of the adhesive system used, no statistically significant difference ($p = 0.387$) in the tooth-restoration interface was observed for all groups (Table 3). However, it was observed that the use of a self-etching system (G2) resulted in the lowest percentage of superficial microhardness change (Figure 1).

This could be explained by the fact that self-etch adhesives are less aggressive to the tooth surface, thus suggesting the formation of a

homogeneous and thin hybrid layer that is resistant to erosive challenge.

Table 2. Microhardness before and after erosive challenge by applying different adhesive systems. Student's t test (n=30).

	Before erosive challenge		After erosive challenge					
	Mean	(±SD)	Protected area			Experimental area		
			Mean	(±SD)	p value	Mean	(±SD)	p value
G1 Adper Single Bond 2	293.5	40.3	255.43	50.47	0.322	173.1	30.9	<0.001
G2 Adper SE Plus	305.8	24.6	282.43	55.28	0.657	196.1	43.7	<0.001
G3 Adper SE Plus + PA	310.9	52.6	273.55	58.27	0.081	183.4	33.6	<0.001

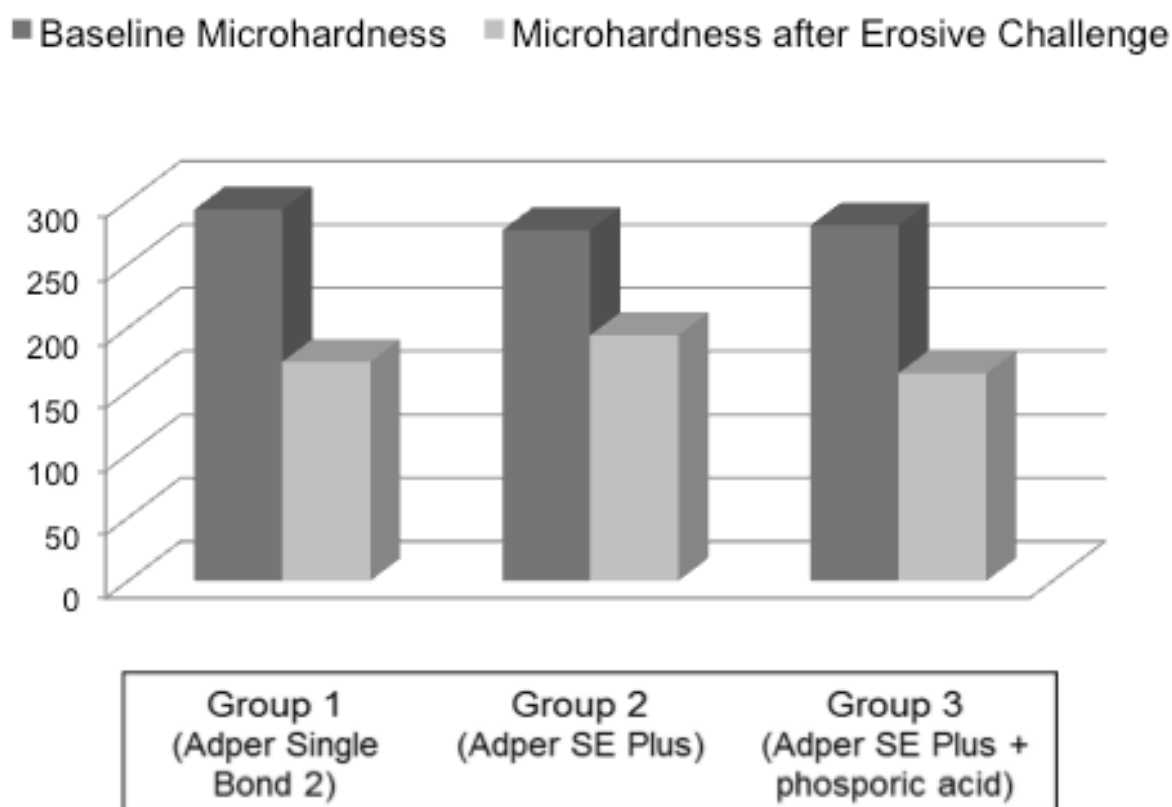
*Microhardness (KNH)

Table 3. Average of the superficial microhardness change (%SMHC) after the application of different adhesive systems and erosive challenge. Two-way ANOVA (n=30).

	%SMHC*	p value
G1 (Adper Single Bond 2)	-39.85	0.38
G2 (Adper SE Plus)	-28.49	
G3 (Adper SE Plus + PA)	-40.00	

*Microhardness (KNH)

Figure 1. Average of superficial microhardness change before and after erosive challenge among the adhesive systems. (n=30)



Several *in vitro* studies assessed the response of different restorative materials to erosive challenge.^{8,30} However, due to the short experimental period, no statistically significant differences were detected. Based on this assumption, a study extended the exposure time of the samples to 35 days and obtained positive significant results when they compared composite resin to glass ionomer cements (conventional or resin-modified). The authors concluded that the material of choice should be composite for patients susceptible to erosive challenge.¹²

In this study, the selected experimental design (erosive challenge with 3 daily cycles of 5 min each, for a period of 5 days) was based on a previously study with a detailed methodology.¹⁰ This study concluded that the greater mineral loss in primary enamel after erosive challenge occurred in the first five days. During a period of 10 to 15 days, a less pronounced homogeneous and gradual loss was observed.¹⁰

From these data, it can be suggested that the hybrid layer has an intrinsic characteristic of acid resistance. The mechanism of hybrid layer formation after applying different adhesive systems (removing low mineral content or modifying the smear layer) increases the probability of complete diffusion of the bonding agent (adhesive) along the full extent of the previously demineralised

tissue. This forms an acid-resistant layer that is less susceptible to erosive challenge.

The self-etch system could be considered as an alternative based on the use of non-rinse acidic monomers that simultaneously etch and prime the tooth tissues. Regarding the sensitivity of the technique, this approach seems to be the most promising clinically, as it eliminates the rinsing phase, which reduces the technique sensitivity and reduces chair time.²¹ Such properties are very advantageous, especially for use in paediatric patients.

However, it should be noted that erosion is a complex phenomenon that involves individual characteristics (eating disorders, gastroesophageal reflux disease) and extrinsic sources of acid (diet, medicaments).¹ Its evolution depends on numerous cumulative factors.^{2-6,8,9,13,20,30} Many studies have been conducted that address its impact on dental substrates.^{2-13,20,30} However, there is not enough evidence available for primary teeth.

CONCLUSION

According to the data obtained, the different adhesive systems tested did not influence the superficial microhardness change after erosive challenge. All groups showed a loss of surface hardness, regardless of the adhesive system used. Self-etch systems demonstrated a greater ability to withstand

erosive challenge at the tooth-restoration interface and could serve as an alternative to restorative procedures in primary teeth. Risk factors, such as dietary habits and the presence of dental erosion, should be considered before undergoing restorative procedures.

These results suggested that further studies should be conducted to understand the impact of erosion on the mechanical and physical properties of the adhesive-restorative material interface in primary teeth.

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